

## **Bering and Chukchi Sea**

### **Sediment Heavy Metal References**

The Sediment Heavy Metal database is maintained to support Pacific walrus research at the Alaska Biological Science Center. We are compiling references to sources of surface-sediment heavy metal concentration data for the Bering and Chukchi Seas.

This is a work in progress. If you know of studies, reports, or data sources which are not included in the database, we would appreciate hearing from you. Please contact Michael Rehberg ([michael\\_rehberg@usgs.gov](mailto:michael_rehberg@usgs.gov)).

The most recent version of this database is available as a Microsoft Access 95 database table and Adobe Acrobat document at [www.absc.usgs.gov/research/bering/metals/lit](http://www.absc.usgs.gov/research/bering/metals/lit)

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<b>ID</b>	1	<b>Type</b>	map	<b>Year</b>	1974
<b>Reference</b>	Barnes, Peter, Kam Leong, and Charles Gustafson. 1974. Map showing distribution of copper, lead, zinc, mercury, and arsenic in the sediments off the coast of northern Alaska. USGS Misc. Field Studies Map MF-614.				
<b>Location</b>	Beaufort Sea: Cape Simpson east to Barter Island, from coastline out to about 2000 m depth contour.		<b>Number of Stations</b>	170 (assumed)	
<b>Metals Sampled</b>	n=170 for each element:  Cu Pb Zn Hg As		<b>Station Coordinates Available?</b>	not available explicitly, but sampling stations are located on a georeferenced map	
			<b>Sampling Depths</b>	upper 2 cm of surface sediment	
<b>Extraction and Analysis Type</b>	Sediment dried and gently ground.  1. Vaughn & McCarthy's atomic absorption for Hg 2. Ward's wet chemical for As 3. Ward's atomic absorption for Cu, Pb, Cd, Zn		<b>Notes</b>	- On the map, isolines show 'above average' concentrations, with point locations showing sample concentrations. - Collected on cruises of USCGC Glacier, R/V Loon, and R/V Natchick	

<b>ID</b>	2	<b>Type</b>	map	<b>Year</b>	1971
<b>Reference</b>	Barnes, Peter and Kam Leong. 1971. Distribution of copper, lead, zinc, mercury, and arsenic in the surface sediments off the coast of northwestern Alaska. USGS Misc. Field Studies Map MF-316.				
<b>Location</b>	Chukchi Sea: Cape Lisbourne to Icy Cape and west to 168 degrees W.		<b>Number of Stations</b>	64 (assumed)	
<b>Metals Sampled</b>	n = 64 for each element:  Cu Pb Zn As Hg		<b>Station Coordinates Available?</b>	not available explicitly, but sampling stations are located on a georeferenced map	
			<b>Sampling Depths</b>	analysis was performed on the surficial sediments (top 2-10 cm)	
<b>Extraction and Analysis Type</b>	Sediment sieved, dried, gently disaggregated.  1. Vaughn & McCarthy's atomic absorption for Hg 2. Ward's wet chemical for As 3. Ward's atomic absorption for Cu, Pb, Zn  detection limit 0.01 ppm for AAS		<b>Notes</b>	<ul style="list-style-type: none"> <li>- baseline study of heavy metals in sediments</li> <li>- isopleth map showing metal concentration trends, with point locations showing sample concentrations</li> <li>- Collected on Western Beaufort Sea Environmental Cruise, USCGC Glacier.</li> </ul>	

<b>ID</b>	3	<b>Type</b>	article	<b>Year</b>	1989
<b>Reference</b>	Sweeney, Michael D. and A. Sathy Naidu. 1989. Heavy metals in sediments of the inner shelf of the Beaufort Sea, northern Arctic Alaska. Mar. Poll. Bull. 20(3):140-143.				
<b>Location</b>	Beaufort Sea: Harrison Bay, Simpson Lagoon-Gwydyr Bay, Stefansson Sound-Prudhoe Bay, Beaufort Lagoon, Open Shelf (all other locations); along ~430km of coastline		<b>Number of Stations</b>	137	
<b>Metals Sampled</b>	Co Cu Ni Cr V Zn Mn Fe		<b>Station Coordinates Available?</b>	no. Sample concentrations are averaged for each of the 5 sampling areas	
			<b>Sampling Depths</b>	Not reported? Used Van Veen & Ekman grab samplers (2 dm <sup>3</sup> ) so max depth = ~20cm	
<b>Extraction and Analysis Type</b>	Interior portion of grab pulverized into powder.  1. Total Metal Abundances: powder digested with HF-HNO <sub>3</sub> . 2. Partial Extractions: extracted with 1-M hydroxylamine hydrochloride in 25% acetic acid. (Releases only portions of heavy metals not bound in crystal lattices.) Analyzed with atomic absorption spectrophotometry.		<b>Notes</b>	<ul style="list-style-type: none"> <li>- Surface sediments collected 1970-1980.</li> <li>- Baseline metal concentrations.</li> </ul>	

<b>ID</b>	4	<b>Type</b>	report	<b>Year</b>	1972
<b>Reference</b>	Nelson, C. Hans, David E. Pierce, Kam W. Leong, and Frank F. H. Wang. 1972. Mercury distribution in ancient and modern sediment of northeastern Bering Sea. USGS Open File Report 533. 34 pp.				
<b>Location</b>	Bering Sea: Cape Prince of Wales, southwest to St. Matthew Is., northeast to Yukon Delta, including Norton Sound.		<b>Number of Stations</b>	132 (some stations had >1 sample taken)	
<b>Metals Sampled</b>	Hg - natural mercury anomalies		<b>Station Coordinates Available?</b>	yes - latitude/longitude	
			<b>Sampling Depths</b>	- surface 1mm, n=20 - surface 0-10 cm, n=169 - subsurface 10-30 cm, n=61	
<b>Extraction and Analysis Type</b>	- Sediment air-dried and gently disaggregated. - Atomic absorption technique: +/- 5% precision detection limit 0.01 ppm @ 0.2g sample size		<b>Notes</b>	- Natural Hg anomalies present since early Pliocene - "Beach entrapment" of heavy metals may increase concentration in nearshore surface sediments. - Depth available for most stations	

<b>ID</b>	5	<b>Type</b>	report	<b>Year</b>	1979
<b>Reference</b>	Gardner, J. V., T. L. Vallier, and W. E. Dean. 1979. Sedimentology and geochemistry of surface sediments and the distribution of faults and potentially unstable sediments, St. George Basin region of the Outer Continental Shelf, southeastern Bering Sea. In: Environ. Assess. of the Alaska Continental Shelf, Final Reports of Principal Investigators, Volume 2: Physical Science Studies. US Dept. of Commerce - NOAA - OCSEAP. pp. 181-271.				
<b>Location</b>	Bering Sea: greater St. George Basin		<b>Number of Stations</b>	69	
<b>Metals Sampled</b>	[all elements sampled are listed] Si, Al, Ca, K, Fe, Ti, S, Mg, Na, Hg, Mn, Ni, Li, Rb, Zn, As, Ge, Sn, B, Ba, Co, Cr, Ga, Cu, Sc, Sn, Sr, V, Y, Yb, Zr, U, Th		<b>Station Coordinates Available?</b>	not available explicitly, but sampling stations are located on a georeferenced map (see Bronson (1989) for coordinates)	
			<b>Sampling Depths</b>	Analysis performed on: - top 3 cm of Van Veen grabs - top 5 cm of gravity and piston cores	
<b>Extraction and Analysis Type</b>	-Air dried, ground  - atomic absorption spectrophotometry. - neutron activation analysis		<b>Notes</b>	- Look in MULDARS for possible digital data and station coordinates. - Surface sediments collected 1976-1977. - Raw data presented in comprehensive table, by station. - Isopleth maps describe concentration regions.	

<b>ID</b>	6	<b>Type</b>	report	<b>Year</b>	1994
<b>Reference</b>	Meador, James P., Robert C. Clark, Jr., Paul A. Robisch, Donald W. Ernest, John T. Landahl, Usha Varanasi, Sin-Lam Chan, and Bruce B. McCain. 1994. National benthic surveillance project: Analysis of elements in sediment and tissue, Cycles I to IV (1984-1988). NOAA Technical Memorandum NMFS-NWFSC-16.				
<b>Location</b>	Oliktok Point, Endicott Field, Chukchi Sea near Kotzebue, Port Moller, Dutch Harbor		<b>Number of Stations</b>	5	
<b>Metals Sampled</b>	Sb, As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Sn, Zn, Al, Fe, Mn, S		<b>Station Coordinates Available?</b>	yes, lat/long	
			<b>Sampling Depths</b>	- Top 2 cm of samples were extruded for analysis. - 3 replicates composited for each sample	
<b>Extraction and Analysis Type</b>	Oven-dried.  Total acid digestion with 6 mL HF & 2 mL HCl:HNO <sub>3</sub> (3:1)  Atomic absorption spectroscopy.		<b>Notes</b>	- Available via ftp. - Samples bottom fish and contaminant levels in associated sediment. - Compares contamination level in sediment and fish.  - Notes that: Metal in lattice structure is extractable only by harsh acid digestion. The amount bioavailable is that present in overlying water, interstitial (pore) water, or sediment ingested by animal.	

<b>ID</b>	7	<b>Type</b>	report	<b>Year</b>	1988
<b>Reference</b>	Bronson, Michael T. 1988. Trace contaminants in surface sediment of the northern Bering Sea: a statistical review. Anchorage, Alaska: Nat. Oceanic and Atmospheric Admin. - Ocean Assessments Division - Alaska Office.				
<b>Location</b>	Bering Sea: north of 63 degrees N		<b>Number of Stations</b>	- Depends on source report.	
<b>Metals Sampled</b>	<ul style="list-style-type: none"> <li>- Used in this statistical analysis: As, Ba, Cd, Cr, Cu, Pb, Hg, Ni, Zn (also organochlorides)</li> <li>- Available in source reports: 17 - 50 elements</li> <li>- Also animal tissue (walrus, misc. invertebrates, fish, spotted seal, bearded seal).</li> </ul>		<b>Station Coordinates Available?</b>	<ul style="list-style-type: none"> <li>- Depends on source report.</li> <li>- Bronson tracked down coordinates missing from some original source reports.</li> </ul>	
			<b>Sampling Depths</b>	<ul style="list-style-type: none"> <li>- This analysis did not consider samples deeper than 10 cm below seafloor.</li> <li>- Source reports used varying depths.</li> </ul>	
<b>Extraction and Analysis Type</b>	<ul style="list-style-type: none"> <li>- Depends on source investigation. Classified into two types:</li> <li>1. Acid-extractable concentrations of sediment reflect trace contaminants from the soluble fraction of the sediment. (see Burrell 1977, 1978).</li> <li>2. Whole-rock fraction examinations also include contaminants bound by the crystal lattice, (is it available to organisms for uptake?)</li> </ul>		<b>Notes</b>	<ul style="list-style-type: none"> <li>- Identifies geographic-, sampling method-, and temporal (investigation-to-investigation)-caused variation among previous sediment sampling efforts.</li> <li>- Includes extensive appendix which contains original data from the source research reports.</li> <li>- Cd, Cu, Hg conc. near Nome differs signif. between investigations; Zn does not.</li> <li>- As, Barium, Cr conc. differs between Nome area and remainder of Norton Basin.</li> <li>- PREVIOUS INVESTIGATIONS USED: Burrell (1977, 1978, 1978), Larsen (1980), Nelson (1977), Patry (1977), Robertson (1979)</li> </ul>	



<b>ID</b>	8	<b>Type</b>	report	<b>Year</b>	1988
<b>Reference</b>	Bronson, Michael T. 1988. Trace contaminants in the greater St. George Basin: a statistical review. Anchorage, Alaska: Nat. Oceanic and Atmospheric Admin. - Ocean Assessments Division - Alaska Office.				
<b>Location</b>	Bering Sea: St. George Basin (approx. 165W west to 174W, and Aleutian Chain north to 59N)		<b>Number of Stations</b>	- Depends on source report.	
<b>Metals Sampled</b>	- Used in this statistical analysis: As, Ba, Cr, Cu, Hg, Ni, V, Zn (also organochlorides) - Available in source reports: 17 - 50 elements  - Also animal tissue (Invertebrates, spotted, ribbon, bearded, N. fur seals ).		<b>Station Coordinates Available?</b>	- Depends on source report. - Bronson tracked down coordinates missing from some original source reports.	
			<b>Sampling Depths</b>	- Core: sample conc. considered an average of upper 30cm sediment - Van Veen: a few cm below surface	
<b>Extraction and Analysis Type</b>	- Depends on source investigation. Classified into two types:  1. Acid-extractable concentrations of sediment reflect trace contaminants from the soluble fraction of the sediment. (see Burrell 1977, 1978). 2. Whole-rock fraction examinations also include contaminants bound by the crystal lattice (is it available to organisms for uptake?)		<b>Notes</b>	- Identifies geographic-, sampling method-, and temporal (investigation-to-investigation)-caused variation among previous sediment sampling efforts. - Includes extensive appendix which contains original data from the source research reports.  - PREVIOUS INVESTIGATIONS USED: Burrell (1977, 1978), Kaplan et al. (1977), Venkatesan et al. (1981), Robertson and Abel (1979), Gardner et al. (1978).	

<b>ID</b>	9	<b>Type</b>	report	<b>Year</b>	1978
<b>Reference</b>	Burrell, David C. 1978. Natural distribution and environmental background of trace heavy metals in Alaskan shelf and estuarine areas. In: Environmental Assessment of the Alaskan Continental Shelf, Annual Reports of Principal Investigators for the Year Ending March 1978. Volume VIII. Contaminant Baselines. NOAA - Outer Continental Shelf Environmental Assessment Program. 199-494.				
<b>Location</b>	-Bering Sea: SE of St. Matthew Is. incl. Bristol Bay; Norton Sound -Chukchi Sea: east of EEZ boundary -Also Gulf of Alaska areas		<b>Number of Stations</b>	51	
<b>Metals Sampled</b>	Cd, Cr, Cu, Fe, Pb, Ni, Zn, V  - Also tissue samples from seals, soluble heavy metal samples from the water, subtidal organisms.		<b>Station Coordinates Available?</b>	yes, lat/long	
			<b>Sampling Depths</b>	-top 2cm (Haps corer) for extracts -various intervals used for total sed. anal.	
<b>Extraction and Analysis Type</b>	1. Readily reducible Hg: sample shaken with seawater of known Hg concentration.  2. Extractable Heavy Metals from Seds: a. 1975-76, reduced with 25% acetic acid - 1 M hydroxylamine hydrochloride, analyzed with atomic absorption analysis. b. 1976-77, leached with 25% v/v acetic acid, analyzed with atomic absorption analysis.		<b>Notes</b>	- Detailed discussion on the "availability" of heavy metals in a form available for bioaccumulation.  - Burrell: also wrote bacteria-to-invert metal uptake paper.  - 1975 Discoverer cruise, 1976 Discoverer cruise, Miller Freeman trawl samples	

<b>ID</b>	10	<b>Type</b>	report	<b>Year</b>	1977
<b>Reference</b>	Burrell, David C. 1977. Natural distribution of trace heavy metals and environmental background in Alaskan shelf and estuarine areas. In: Environmental Assessment of the Alaskan Continental Shelf, Annual Reports of Principal Investigators for the Year Ending March 1977. Volume XIII. Contaminant Baselines. NOAA - Outer Continental Shelf Environmental Assessment Program. pp. 290-506.				
<b>Location</b>	-Beaufort Sea, n=11 -Norton Sound/S. Chukchi Sea, n=31 -S. Bering Sea, n=33 -also Gulf of Alaska areas		<b>Number of Stations</b>	33+25	
<b>Metals Sampled</b>	Cd, Cu, Ni, Zn, Fe, Mn, V, Cr, Se, As, Ba, Co, Sb, Hg, Ni		<b>Station Coordinates Available?</b>	yes, lat/long	
			<b>Sampling Depths</b>	-top 2cm for extracts -various intervals used for total sed. anal.	
<b>Extraction and Analysis Type</b>	1. Total Sediment/Whole-Rock Mn, V, As, Ba, Co, Cr, Fe, Sb, Hg, Zn, Ni, Cu Neutron activation analysis  2. Extractable Fractions Analysis Cd, Cu, Ni, Zn, Fe, Mn, V, Cr, Se Gas-liquid chromatography or furnace atomic absorption		<b>Notes</b>	- Progress report; not all analyses may be presented. Look at final reports. - Metal analysis results are presented on several maps and in data tables.	

<b>ID</b>	<input type="text" value="11"/>	<b>Type</b>	<input type="text" value="report"/>	<b>Year</b>	<input type="text" value="1979"/>
<b>Reference</b>	<input type="text" value="Burrell, David C. 1979. Distribution and dynamics of heavy metals in Alaskan shelf environments subject to oil development. Final Report: OCSEAP Research Unit 162. In: Outer Continental Shelf Environmental Assessment Program, Final Reports of Principal Investigators, Volume 33 - July 1985. pp.1-101."/>				
<b>Location</b>	<input type="text"/>	<b>Number of Stations</b>	<input type="text"/>		
<b>Metals Sampled</b>	<input type="text"/>	<b>Station Coordinates Available?</b>	<input type="text"/>		
		<b>Sampling Depths</b>	<input type="text"/>		
<b>Extraction and Analysis Type</b>	<input type="text"/>	<b>Notes</b>	<input type="text" value="- Summarizes the work done on this OCSEAP project. Identifies the previous reports which contain data for given locations and years."/> <input type="text" value="- Lists references to papers where the data analysis from work done on this project will be presented:"/> <input type="text" value="Burrell, D.C. Some heavy metal contents of Bering S. seals."/> <input type="text" value="Burrell, D.C. et al. Some geochemical characteristics of Bering S. sediment. In: Bering Sea Symposium Volume."/>		

<b>ID</b>	12	<b>Type</b>	report	<b>Year</b>	1980
<b>Reference</b>	Larsen, B. R., C. H. Nelson, C. Heropolous, and J. J. Patry. 1980. Distribution of trace elements in the bottom sediment of the northern Bering Sea. Final Report: OCSEAP Research Unit 413. In: Outer Continental Shelf Environmental Assessment Program, Final Reports of Principal Investigators, Volume 33 - July 1985. pp. 195-314.				
<b>Location</b>	Bering Sea: Norton Basin, east of EEZ line, and surrounding St. Lawrence Is.		<b>Number of Stations</b>	180	
<b>Metals Sampled</b>	> 50  [Table of elements ("Table I") is missing from report.] Partial List: V, Ni, Zr, Sn, Cr, Ce, Cu, Pb, Zn, Fe, Mn, Co, Ba, Ti, Ca, Mg, Na, K, Al, P, Sr, Sc, Ga, La, Nb, B, Y, Yb, Be, Ag, Mo, As, Sb, Cd		<b>Station Coordinates Available?</b>	no	
			<b>Sampling Depths</b>	1968-70: Van Veen grab, top 5-10 cm 1976-77: Soutar Van Veen grab; subsamples taken from top 0-2 cm	
<b>Extraction and Analysis Type</b>	-Air-dried at 110°C, homogenized.  -Sample analyzed using semi-quantitative optical emission spectroscopy.  "...although not as precise as other analytic techniques, yields values that are adequate to delineate regional trends."		<b>Notes</b>	Final report for the OCSEAP sediment metal project in this region.  -2-D isopleth maps of many element concentrations. -3-D value-surface maps identify peaks of element concentrations.	

<b>ID</b>	13	<b>Type</b>	report	<b>Year</b>	1979
<b>Reference</b>	Burrell, David C. 1979. Distribution and dynamics of heavy metals in Alaskan shelf environments subject to oil development. In: Environmental Assessment of the Alaskan Continental Shelf, Annual Reports of Principal Investigators for the Year Ending March 1979. Volume V. Receptors -- Microbiology Contaminant Baselines. NOAA - Outer Continental Shelf Environmental Assessment Program. pp. 326-546.				
<b>Location</b>	-Gulf of Alaska areas only -Beaufort Sea: sampled this year, but results not presented here. -Bering Sea: no field work; analysis continues		<b>Number of Stations</b>		
<b>Metals Sampled</b>			<b>Station Coordinates Available?</b>		
			<b>Sampling Depths</b>		
<b>Extraction and Analysis Type</b>	1. Total sediment/whole rock analysis: AAS  2. Extractable fractions analysis: using freeze-dried sediments, 2-step leaching process used.: a. H2O2 extraction: releases metals organically bound; analyzed with AAS b. 0.3 N Hcl extraction: releases weakly bound inorganic associates; analyzed with AAS		<b>Notes</b>	- Aquaria experiments on food chain transfers of heavy metals described here. Pathway of Cd through a biological food web: bacteria - sediment - clam.  -Rewrite of paper "Heavy Metal Contents of Bering Sea Seals" [in Appendix III]. Metal levels by seal location.	

<b>ID</b>	14	<b>Type</b>	report	<b>Year</b>	1989
<b>Reference</b>	Bronson, Michael T. 1989. Mercury in Alaska marine surface sediments: a review of the regional data. Final Report: OCSEAP Research Unit 691.				
<b>Location</b>	-Bering Sea: northern; St. George Basin, Sag Delta, off Nome -Chukchi Sea -Beaufort Sea		<b>Number of Stations</b>	Varied by study.	
<b>Metals Sampled</b>	Hg, n=444 (all studies combined)		<b>Station Coordinates Available?</b>	No.	
			<b>Sampling Depths</b>	Varied by study: 2-30 cm.	
<b>Extraction and Analysis Type</b>	Varied by study: AAS or NAA		<b>Notes</b>	-Analysis of data collected by prev. studies: Barnes et al. (1974), Barnes and Leong (1971), Nelson et al. (1972), Gardner et al. (1979), Burrell (1978), NORTED (1982), Rusanowski et al. (1988)  - [from abstract] Hg concentrations reported by 8 studies of surf. sed. varied significantly among regions of the Alaska shelf. Chukchi indicated lowest Hg geometric means. One Beaufort study reported highest concentrations. Hg levels did not differ signif. bet. mud & sand fractions when data combined among studies. (Diffs. in methods may have affected Hg estimates bet.	